

Fermi National Accelerator Laboratory

P.O. Box 500, Batavia, Illinois 60510

Phone: 630-840-3106

FAX: 630-840-2677

**Accelerator Division Engineering**

February 14, 2013

Subject: Requirements for a Loss Monitoring System

for Thinly Shielded Enclosures

# Introduction

Total Loss Monitors (TLMs) are being considered for use in Radiation Safety Systems at Fermilab to limit the intensity and duration of unintended beam losses. As we enter the intensity frontier, the requirement for passive shielding of existing and future accelerators and beam lines for the range of beam loss scenarios must be reexamined. For existing accelerators and beam lines, the tunnel structural design generally precludes the possibility of adding additional earth shielding. In cases, where additional shielding might be added, the additional of earth shielding could be of limited benefit and would be costly.

An alternative to the addition of earth shielding is the installation of fences and radiological postings. While fences and signs are a permitted option by the Fermilab Radiological Control Manual (FRCM), these can be expensive to install, require continued vigilance to ensure that integrity is maintained. Weather elements including occasional high winds, rain, snow, and snow plowing are factors that make such vigilance necessary. Fences could impede worker access to service buildings for equipment maintenance, impede worker access to shielding berms, and add a layer of complication and delays in the form of checking out keys, signing radiation work permits, etc.. Signs exposed to the elements often fade over time and require similar attention and occasional replacement.

In addition, the potential for worker exposure within posted areas is generally avoided by the imposition of the additional requirement that work is not permitted while beam is on; in essence, maintenance activities and beam operations cannot coexist. The coordination of operations and maintenance activities is complicated by this requirement. Also, as a consequence, accelerator/beam line maintenance activities are often delayed.

The laboratory is open to the public. In general, the impression of danger that radiation signs and fences produce for the uninformed public greatly outweighs the actual impact of radiation fields that might be present. The signs and barriers are used to control radiation exposure for workers and non-workers to the safe limits prescribed by various regulatory and guidance documents. The public perception of the purpose of the barriers and signs varies widely and is rarely coincident with their intended purposes. For this reason, the use of such barriers and signs should be limited if possible to cases where no alternative exists.

The use of thick passive shielding for new, powerful accelerators and beam lines is also impractical. Unlimited occurrences of very high beam power losses cannot be sustained. Orbit control of very high energy/ intensity is of utmost importance to prevent irreversible damage to costly accelerator beam line components. In the case of cryogenically cooled components such as certain RF cavities, low power losses must be automatically sensed. By their very nature, high power accelerators are self-limiting in the extent and duration of beam loss. The role to be played by passive shielding needs to be defined in conjunction with these other inherent beam power loss limitations.

TLMs can be used to limit beam losses over extensive regions in accelerator/beam line enclosures. The applications for TLM use include the limitation of radiation dose rate outside of passive shielding, the limitation of radiation sky-shine over extended areas, the control of residual radiation dose rate to workers due to beam loss within accelerator/beam line enclosures , and finally to limit activation of air, surface water and ground water.

# **Requirements-Mandatory**

1. The TLM system must be able to limit beam losses to the level of 1 watt/meter which has become the acceptable loss limit that still allows maintenance activities on tunnel components.
2. The TLM system must be made to connect directly to the existing Radiation Safety System, preferably into the existing Chipmunk or Scarecrow radiation interlock cards.
3. The TLM system must be fail safe:
   1. If the readout electronics loses power, the Radiation Safety System(RSS) must be disabled.
   2. If a TLM chamber is disconnected from its readout electronics, the RSS must be disabled.
   3. The TLM must have a self-check heartbeat that matches the existing heartbeat from the Chipmunk or Scarecrow. A minimum signal needs to be monitored that will satisfy the readout card heartbeat requirement. The loss of such signal must cause the RSS to be disabled.
   4. If the TLM High Voltage supply falls outside of the set range (adjustable as required), the RSS must be disabled.
   5. The TLM source gas supply pressure must be monitored. If the gas source pressure drops below a nominal range, approximately 100 psig, the RSS must be disabled.
   6. Gas flow is important to prevent the buildup of polyethylene out-gas poisons.  The gas flow at the exit of the TLM, or a chain of TLMs, must be monitored. In the event gas flow is reduced below a predetermined range, the RSS must be disabled. ***Note:*** Very low flow is sufficient, e.g. 25 cc/min.
   7. The TLM electrometer must be able to collect charge with a 100% duty factor, i.e., no dead time for integrator reset. ***Note:*** The existing Chipmunk and Scarecrow devices use a quantized charge removal system. This provides rate information proportional to the radiation field being measured.
   8. A calibration schedule and procedure for the readout electronics must be developed.
   9. The response of the TLMs must be characterized for different beam losses.

# Requirements-Desirable

1. The gas species has a dramatic effect on TLM sensitivity. The gas thermal conductivity should be monitored to guard against an incorrect gas bottle being connected to the system. If thermal conductivity of the gas falls out of the normal range, the RSS should be disabled.

# Applicable Standards

1. **FESHM Chapter 1070 - Fermilab Work Smart Set** as applicable.